Sfermion production at a Linear Collider at one-loop

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hep-ph/0401092

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hep-ph/0311149

LCWS Paris, April 2004
MOTIVATION

• At a future $e^+e^-$ LC measurements with high precision possible → requires accurate theoretical predictions including radiative corrections

• LC allows high precision determination of SUSY parameters

• Sfermion production ideal for determination of sfermion mass matrix parameters

• Some sfermions are expected to be light (e.g. light stop due to large mixing)

• SPS1a scenario includes light sleptons

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RADIATIVE CORRECTIONS TO SFERMION PRODUCTION

existing results:

- QCD corrections to colored scalar particle production in SM
  [Drees, Hikasa ’90]
  [Hikasa, Hisano ’96]

- SUSY-QCD corrections to sfermion production within MSSM
  [Arhrib, Capdequi-Peyranere, Djouadi ’95]
  [Eberl, Bartl, Majerotto ’96]

- Yukawa corrections without box contributions
  [Eberl, Kraml, Majerotto ’99]

calculations presented here:

- weak corrections to $e^+e^- \rightarrow \tilde{f}_i \tilde{f}_j$ for $f = t, b, \tau, \nu_\tau, u, d$

- QED corrections split off

- included already calculated QCD
CALCULATION OF $e^+ e^- \rightarrow \tilde{f}_i \tilde{f}_j$

- all diagrams calculated analytically & checked with FeynArts/FormCalc on amplitude level
- numerical evaluation using LoopTools

**some details**

- 't Hooft-Feynman gauge
- $\overline{\text{DR}}$ regularization scheme used for UV divergencies
- **on-shell renormalization scheme** with $\alpha(m_Z)$ as input
- **on-shell input parameters** for SPS1a obtained from $\overline{\text{DR}}$ parameters as

$$X^{OS} = \hat{X}(Q) - \delta X(Q)$$
SLEPTON PRODUCTION (3rd gen.)

STAUS

$\sigma(e^+e^- \rightarrow \tilde{\tau}_i \tilde{\tau}_j)$ [fb]

$\tilde{\tau}_1 \tilde{\tau}_1$
$\tilde{\tau}_2 \tilde{\tau}_2$
$\tilde{\tau}_1 \tilde{\tau}_2 + c.c.$

$\sqrt{s}$ [GeV]

TAU-SNEUTRINO

$\sigma(e^+e^- \rightarrow \tilde{\nu}_\tau \tilde{\nu}_\tau)$ [fb]

$\sqrt{s}$ [GeV]

$\tilde{\tau}_1 \tilde{\tau}_2$ — RELATIVE

$\Delta\sigma/\sigma^0(\tilde{\tau}_1 \tilde{\tau}_2)$ [%]

$\Delta$prop
$\Delta$vertex
$\Delta$box
$\Delta$total

$\sqrt{s}$ [GeV]

$\tilde{\nu}_\tau \tilde{\nu}_\tau$ — RELATIVE

$\Delta\sigma/\sigma^0(\tilde{\nu}_\tau \tilde{\nu}_\tau)$ [%]

$\Delta$prop
$\Delta$vertex
$\Delta$box
$\Delta$total

$\sqrt{s}$ [GeV]
SQUARK PRODUCTION (3rd gen.)

STOPS

\[ \sigma(e^+e^- \to t_1\bar{t}_1) \text{ (fb)} \]

\[ \sqrt{S} \text{ (GeV)} \]

\[ t_1t_1, t_2t_2, t_1t_2 \]

\[ \Delta \sigma/\sigma \text{ (e}^+e^- \to t_1t_2) \text{ (%)} \]

\[ \sqrt{S} \text{ (GeV)} \]

\[ \Delta \text{TOTAL}, \Delta \text{SUSY-QCD}, \Delta \text{PROP}, \Delta \text{VERTEX}, \Delta \text{TOTAL-EW}, \Delta \text{BOX} \]

PLOTS FROM A. ARHRIB, W. HOLLIK

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SQUARK PRODUCTION (3rd gen.) cont.

SBOTTONS

$\sigma(e^+e^- \rightarrow b_1 b_1)$ (fb)

$\sqrt{S}$ (GeV)

$\Delta \sigma/\sigma_0 (e^+e^- \rightarrow b_1 b_1)$ (%)

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SQUARK PRODUCTION (1st & 2nd gen.) + $A_{FB}$ ASYMMETRY

**UP-TYPE SQUARKS**

\[ \sigma(e^+e^\rightarrow \tilde{u}_i\tilde{u}_j) \text{ [fb]} \]

\[ \sqrt{s} \text{ [GeV]} \]

**DOWN-TYPE SQUARKS**

\[ \sigma(e^+e^\rightarrow \tilde{d}_i\tilde{d}_j) \text{ [fb]} \]

\[ \sqrt{s} \text{ [GeV]} \]

**$A_{FB}$ FOR STOPs**

\[ A_{FB} \]

\[ \sqrt{s} \text{ [GeV]} \]

**$A_{FB}$ FOR SBOTTOMs**

\[ A_{FB} \]

\[ \sqrt{s} \text{ [GeV]} \]
POLARIZATION \((e^- \text{ beam polarized})\)

**POLARIZED \(\tilde{t}_1 \tilde{t}_2\)**

\[
\sigma(e^+e^- \rightarrow \tilde{t}_1 \tilde{t}_2) \quad [\text{fb}]
\]

\[
\sigma_L, \sigma_R
\]

**POLARIZED \(\tilde{\tau}_2 \tilde{\tau}_2\)**

\[
\sigma(e^+e^- \rightarrow \tilde{\tau}_2 \tilde{\tau}_2) \quad [\text{fb}]
\]

\[
\sigma_L, \sigma_R
\]

**POLARIZED \(\tilde{b}_2 \tilde{b}_2\)**

\[
\sigma(e^+e^- \rightarrow \tilde{b}_2 \tilde{b}_2) \quad [\text{fb}]
\]

\[
\sigma_L, \sigma_R
\]

**POLARIZED \(\tilde{\nu}_\tau \tilde{\nu}_\tau\)**

\[
\sigma(e^+e^- \rightarrow \tilde{\nu}_\tau \tilde{\nu}_\tau) \quad [\text{fb}]
\]

\[
\sigma_L, \sigma_R
\]

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CONCLUSIONS & OUTLOOK

• Sfermion production supposed to be observed at a future LC

• Radiative corrections not negligible ($\sim -10\%$) when high precision results available

• Box corrections are important at high energies

• Sfermion production ideal for sfermion mass matrix parameters fixing

OUTLOOK:

• Full $\mathcal{O}(\alpha)$ corrections - extending current calculation to include full bremsstrahlung